HS2.3.5-11751: Evaluating the effect of river restoration techniques on reducing the impacts of outfall on water quality

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Introduction

Urban developments release of a variety of heavy metal pollutants which enter rivers through outfall discharge. This results in local nutrient enrichment with adverse effects on the surrounding river ecosystem. Set-back outfalls indirectly discharge into rivers, aiming to reduce pollutant levels by dissipating energy before reaching the main channel. Riparian vegetation reduces sediment generation by decreasing flow velocities, acting as a sediment trap and buffering delivery. It is expected that the ability of the river to remove outfall pollutants will decrease with increased modification to the channel and surrounding land-use.

This study aimed to investigate the following:

- Identify the influence of un-natural channel conditions and channel modification on the ability of a river to deal with outfall pollutants.
- Assess the impact of outfalls on the concentration of pollutants.
- Analyse the differing impact of direct or set-back outfalls.

Figure 1: Set-back and direct outfalls within the study catchment.

Methods

28 stormwater outfalls (18 direct, 10 set-back) in Johnson Creek, Portland Oregon were analysed (see Figure 2). Sediment samples were taken adjacent to, upstream and downstream of the outfall pipe. At set-back outfalls an additional sample was taken at the junction of set-back and main channel.

Sediment samples were sieved and material <2mm was analysed for 14 pollutants; Pb, Zn, Ma, Cu, Ni, Cr, Ca, Mg, Sn, Ba, Na, K, Cd and P.

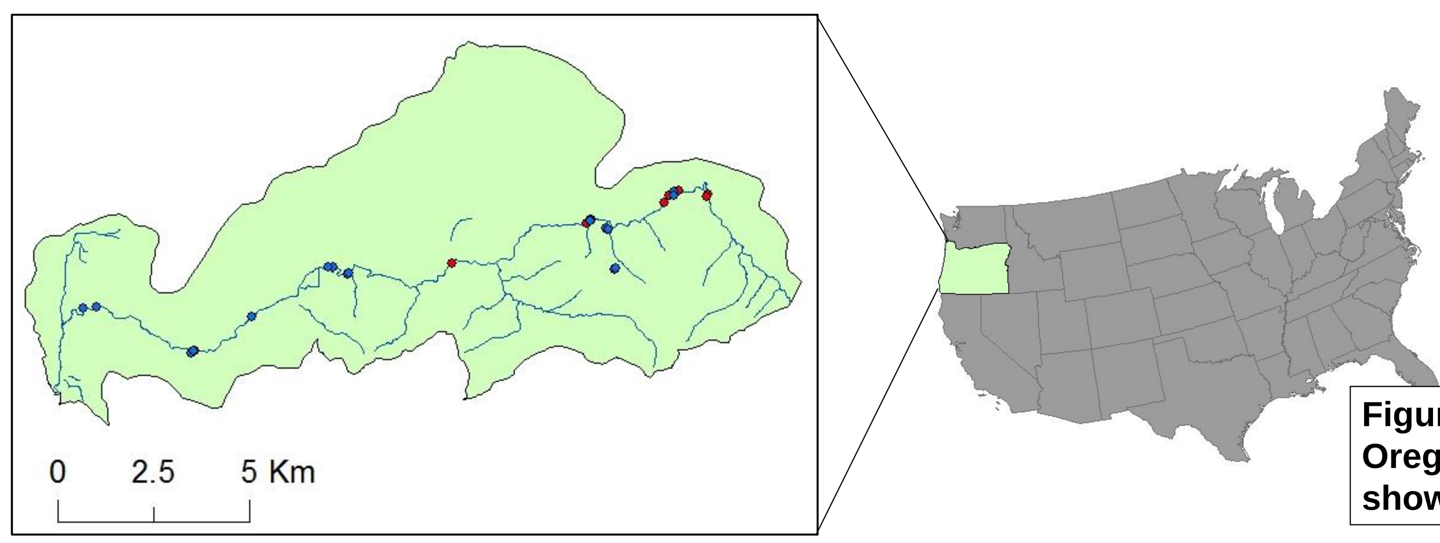

Figure 2: Johnsons Creek, Portland, Oregon USA. Direct outfall sample points shown in blue, Set-back red.

Habitat Quality Assessment (HQA) and Modification scores were calculated at each site (see Raven et al, 1998). An un-natural score, encompassing factors from both HQA and Modification scores and further land-use data was calculated. Percentage change in pollutant levels between upstream and outfalls was calculated. Change between outfall and downstream, as a function of change between upstream and outfall, was also calculated.

Results

- All pollutants observed showed an average increase in concentration at outfalls compared to upstream locations, ranging from 3-275%.
- 11 (of 14) pollutants showed higher average percentage increase at direct outfalls than set-back. Paired-sample t-test indicates a statistically significant difference at the 95% level ($t=2.253$, $p=0.042$).
- Variability of pollutant concentration change is greater at direct outfalls for all pollutants (see Figure 3).

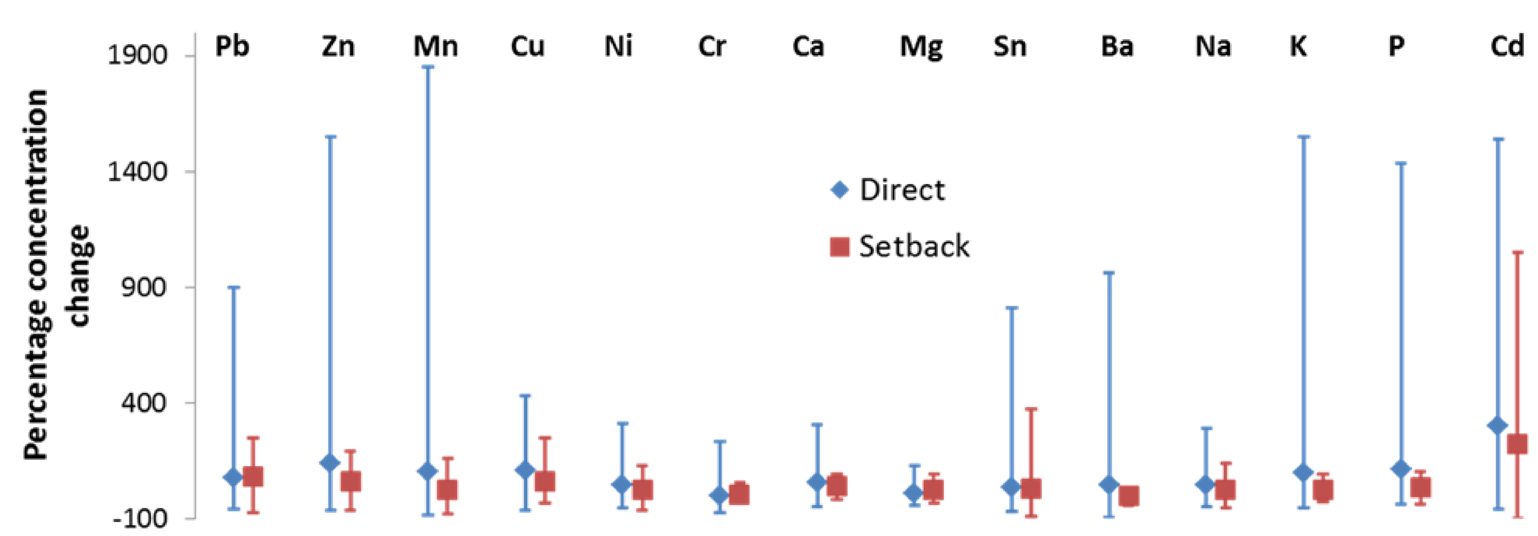

Figure 3: Percentage pollutant concentration change between upstream and outfall. Points show averages, error bars indicate the range of observed values.

- K showed statistically significant negative correlations with un-natural and modification scores at 99% and 95% levels respectively and a positive correlation with HQA.
- Mn and Mg showed similar trends.
- Zn was the only element to show the opposite of the hypothesised change; positive correlation with HQA, however un-natural and modification scores showed no correlation.

Table 1: Significant correlations from pollutant analysis. Orange and yellow squares indicate 99% and 95% confidence levels respectively.

	K	Mn	Mg	Zn
Un-natural	-0.491	-0.361	-0.351	0.082
Modification	-0.404	-0.441	-0.128	0.238
HQA	0.310	0.410	0.175	-0.394

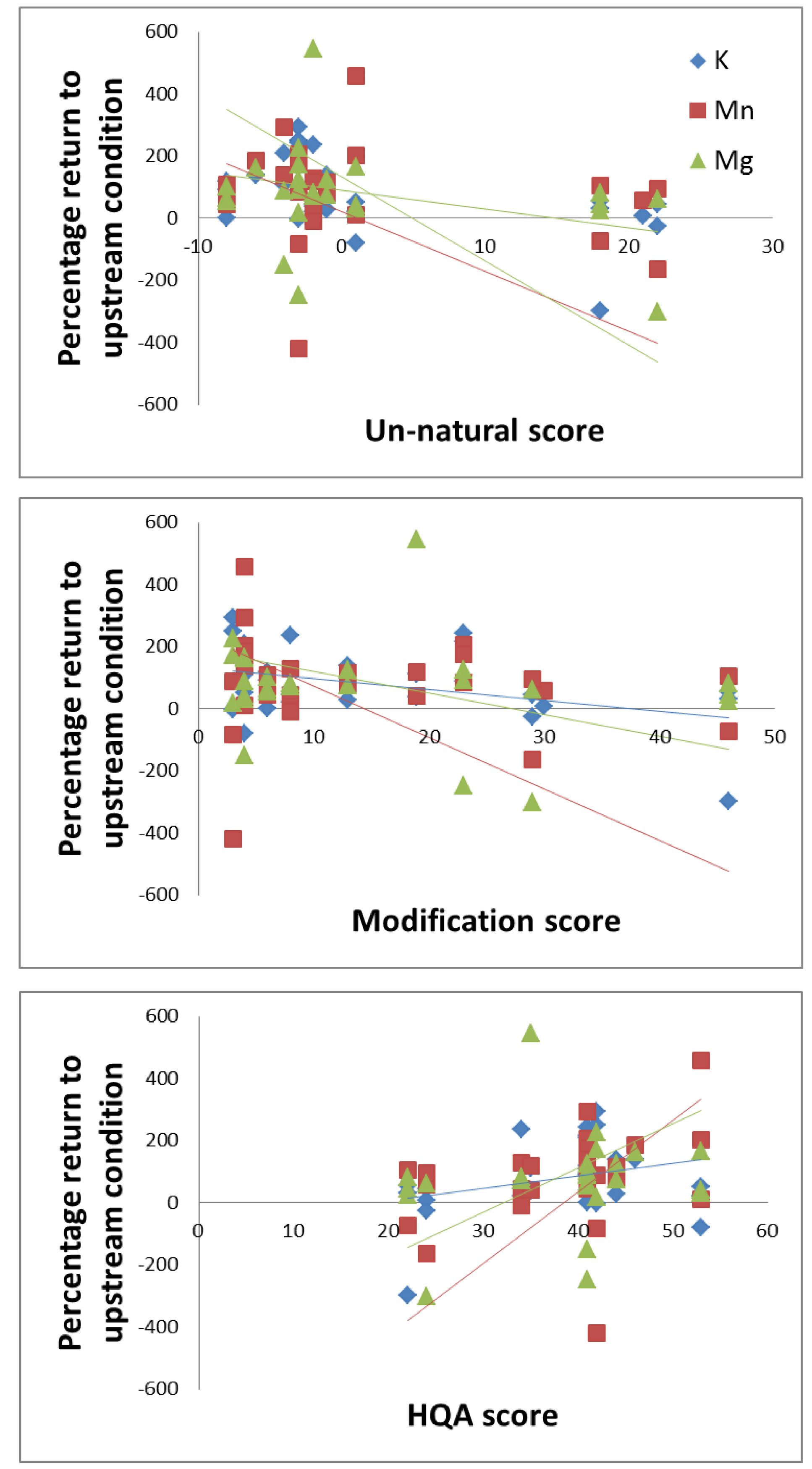

Figure 4: Scatterplots of K, Mn and Mg against Un-natural score, Modification score, and HQA score.

Conclusions

- The results highlight the impact of outfalls on water quality.
- Set-back outfalls appear to ameliorate pollutant concentrations.
- Pollutant concentrations downstream of outfalls relative to upstream significantly increase with the level of modification of the river from its natural state.
- Restored reaches have an increased capacity to remove/store pollutants.
- The results provide a preliminary insight into the benefit of channel restoration for pollutant management.

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